Case Study 305

Condensing gas boilers in galleries, museums and libraries

- Running cost savings of 10-20%
- Payback under 5 years
- High efficiencies using conventional system design
- Easy to install and maintain
- Reduced CO_2 emissions

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

WALKER ART GALLERY, LIVERPOOL

Overview

Energy is usually the largest manageable outgoing in running buildings, and can be responsible for half of the total operating costs. In a public gallery, museum or library, space heating and hot water are two of the largest overheads, but they are potentially among the most controllable.

Heating and hot water in buildings such as these consume, on average, some 160 kWh/m^2 of energy each year. Managers and engineers responsible for making savings in energy use and costs should consider the benefits of installing condensing gas boilers. Using proven technology, these offer savings of 10-20% in the annual fossil fuel bill, and a corresponding reduction in harmful emissions.

Space heating costs in public buildings account for roughly £60 million each year. If only one-third of existing boiler plant were replaced by condensing gas boilers, conservative estimates indicate that this measure alone would lead to annual savings of £6 million. In most cases the investment required would be repaid in less than five years.

Condensing boilers also provide a cost-effective way of reducing pollution and conserving natural resources. Energy consumption in public buildings leads to 1.6 million tonnes of carbon dioxide (CO_2) entering the atmosphere every year, adding to the greenhouse effect. Condensing boilers could reduce this by 150 000 tonnes/yr and also help to prevent acid rain.

This Case Study discusses examples of good practice applications using condensing gas boilers in two public buildings, one a major art gallery built a hundred years ago, the other a library and arts centre dating from the 1970s. The results show that condensing boilers can offer very attractive payback periods in a wide range of circumstances.

Walker Art Gallery

- No apparent additional maintenance cost for condensing boilers
- Additional savings of £1450/year attributable to condensing boiler
- Energy Manager has carried out similar installations at other locations

WALKER ART GALLERY, LIVERPOOL

Named after a local alderman who funded the construction of the original building in the late 1800s, the Walker Gallery is a heavyweight sandstone building in neoclassical style with an imposing portico frontage. It has a mainly pitched slate roof with a series of lightwells to utilise natural light in the galleries. Windows are single glazing in wooden frames with secondary double glazing added in parts. The older section of the building is on three storeys with a more recent addition (around 1930) on two storeys.

Over 200 000 people visit the gallery each year. It houses an internationally important collection of paintings and sculpture, and is particularly rich in European Old Masters and Victorian and Pre-Raphaelite works. Roughly one-third of the 9000 m^2 of floor space is display area. The basement is used for picture storage while the ground floor provides an impressive foyer with tea room, administration offices and award-winning sculpture gallery. Alongside a conservation workshop the first floor provides 19 galleries displaying paintings, including works by Gainsborough, Turner, Cezanne and Rembrandt. The galleries are open to the public between 10.00 and 17.00 Monday to Saturday and 12.00 to 17.00 on Sundays.

System

Until the 1980s the building was heated by steam from a nearby district heating scheme which supplied four major buildings. Costs were apportioned on the basis of floor area, which was seen as a disincentive to managing energy. A mixture of skirting convectors, underfloor heating and radiators was installed during a building upgrade in the early 1900s.

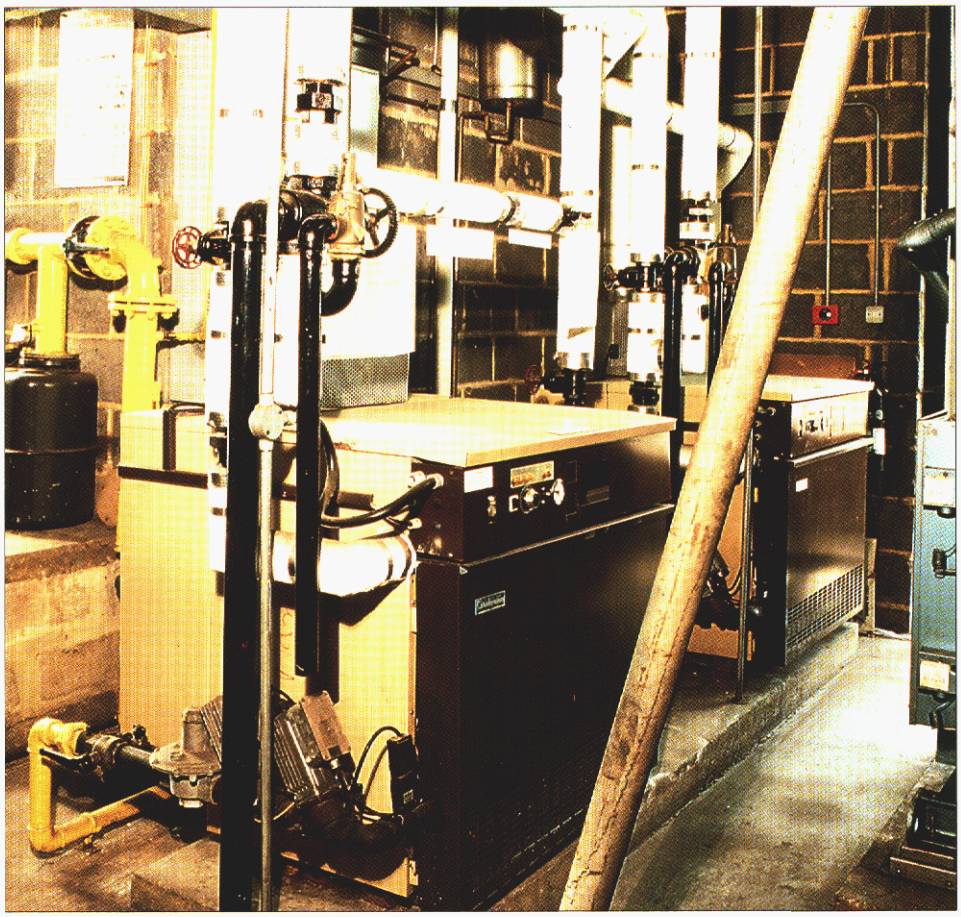
LEIGHTON BUZZARD LIBRARY

opportunity was taken to move to a highly efficient system using condensing boilers and, although this increased the capital cost to £16 000, the predicted payback period remained very attractive at around two years. Conversion took place in 1986 and the resulting energy consumptions have been carefully monitored in order to confirm that the savings predicted have actually been achieved.

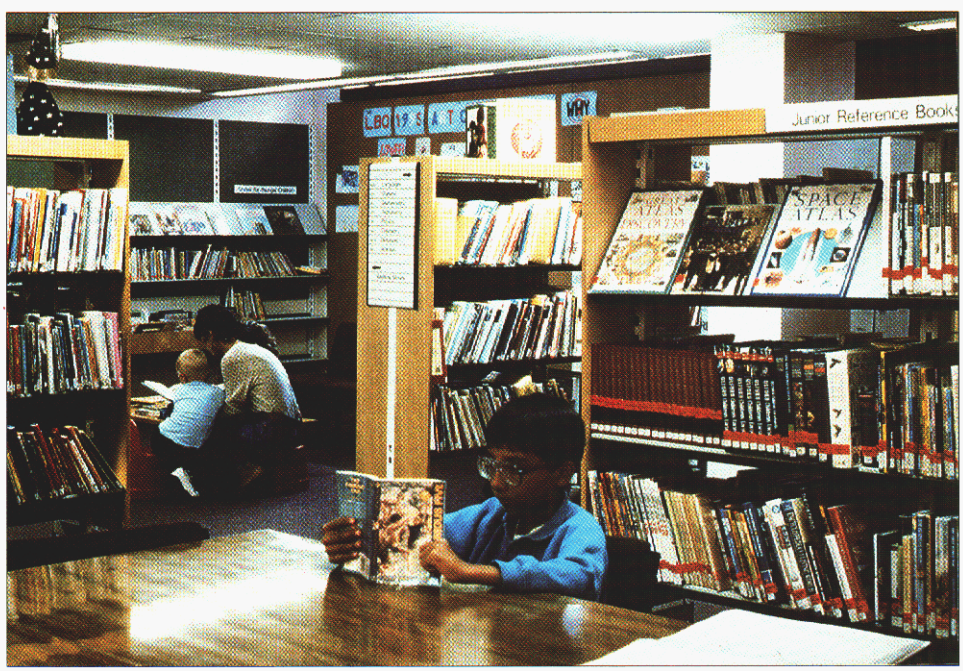
Two Potterton Derwent gas-fired condensing boilers, each rated at 173 kW, have replaced the two 135 kW electric flow heaters. The original system was designed on relatively low water temperatures using the thermal store, and the conversion therefore provided the ideal opportunity for condensing boilers. By using the thermal store, design return water temperature of 40°C can be achieved, ensuring that the boilers operate in the condensing mode for the majority of the heating season. The result is a seasonal efficiency of around 90%. The year-round domestic hot water load is supplied separately by a gas-fired storage water heater, in order to maintain high efficiencies in the summer months when the condensing boilers are switched off.

Two separate chimneys rise up through the boilerhouse roof, constructed of stainless steel in order to resist the corrosive nature of any condensate formed in the flue. The flue terminals do not have any cowls or caps as these could prevent good dispersal of combustion products. Each boiler and flue has a separate condensate drain with a trap to prevent flue gases entering the boiler room. However, the installation would have benefited by avoiding the use of copper as a drainage material as it is highly susceptible to corrosion from condensate. A standard plastic waste pipe would have sufficed.

System control was originally provided by a simple time switch, but this has now been upgraded to an optimum start controller in order to achieve even greater savings during building warm-up periods. As it is a fully condensing installation, the two boilers are sequenced to avoid plant firing unnecessarily and the order is rotated to prevent excessive wear on one unit.



Gas-fired condensing boilers



Leighton Buzzard library

Economics

Monitoring has confirmed that a payback period of around 2.5 years has indeed been achieved based on the cost of electricity saved from the previous system. The annual savings of over £3200 have therefore easily justified the initial outlay.

Had the previous system been conventional gas boilers, the condensing boilers would still have provided a five-year payback. Installing a mixture of high efficiency and condensing boilers would have reduced the capital cost with only a small effect on the savings and hence a payback less than five years.

Reactions

The low temperature water system at Leighton Buzzard Library provided an ideal opportunity for condensing boilers to achieve very high seasonal efficiencies and a rapid return on investment. The designer is very pleased with the operation of the system, which has lived up to all his expectations.

Maintenance requirements are no more than for a conventional boiler, and certainly less than for the electric system which scaled up frequently. The Energy Manager has confirmed the savings and payback period by monitoring the bills closely, and is very happy with the overall performance of the plant. Bedfordshire County Council has been sufficiently impressed that it has installed condensing boilers in other buildings. It now considers installing this type of highly efficient heating plant in every possible circumstance.

Leighton Buzzard Library

- Maintenance cost reduced
- Annual savings of over £3200
- Bedfordshire County Council has installed condensing boilers in other buildings

LEIGHTON BUZZARD LIBRARY

Leighton Buzzard Library and Arts Centre was officially opened in 1979 and is the leading venue for performing arts, visual arts and literary events in the area. Facilities include a 170-seat theatre, meeting rooms, exhibition areas, a bar and coffee lounge, alongside a library of some 70 000 books and records.

Situated in the centre of the town, the building is a three-storey structure with a concrete frame and brick infill. It has a slightly pitched roof and is single glazed throughout. The library, open six days a week, is situated on the ground and first floors, with the arts centre, which holds three or four major events each week, on the second floor.

Bedfordshire County Council has reduced the £25 800 overall annual energy bill of the building by 12% since installing gas-fired condensing boilers.

The original heating and lighting systems were designed to operate in an integrated manner. Air supplied from two main air handling units, heated in winter and cooled in summer, is extracted back through the light fittings in order to recover as much heat as possible. Two electric flow boilers supplied hot water to the air handlers and a reciprocating chiller supplied chilled water in the summer. By the mid-1980s the heating was not operating efficiently and the council was faced with excessive fuel bills.

System

The original electric boilers were designed to run at night to take advantage of the off-peak tariff, and the system incorporated a 4000 gallon thermal storage vessel. However, the adventitious gains were much lower than the design allowed for, which meant that the boilers operated for significant periods during the day using expensive on-peak electricity.

In 1986 the council's Energy Management Group decided to convert the system to gas, with a possible payback of around one year based on a capital cost of £8000. The

An energy survey carried out in 1986 recommended a range of measures including improved air-conditioning control to avoid simultaneous heating and cooling, and improvements to the domestic hot water system. It also suggested the possibility of introducing photoelectric lighting control to take advantage of daylighting from lightwells. Air handling units now provide full air-conditioning to six of the major galleries. Conditions in these rooms are controlled within tight limits by a building energy management system to maintain the integrity of the works of art.

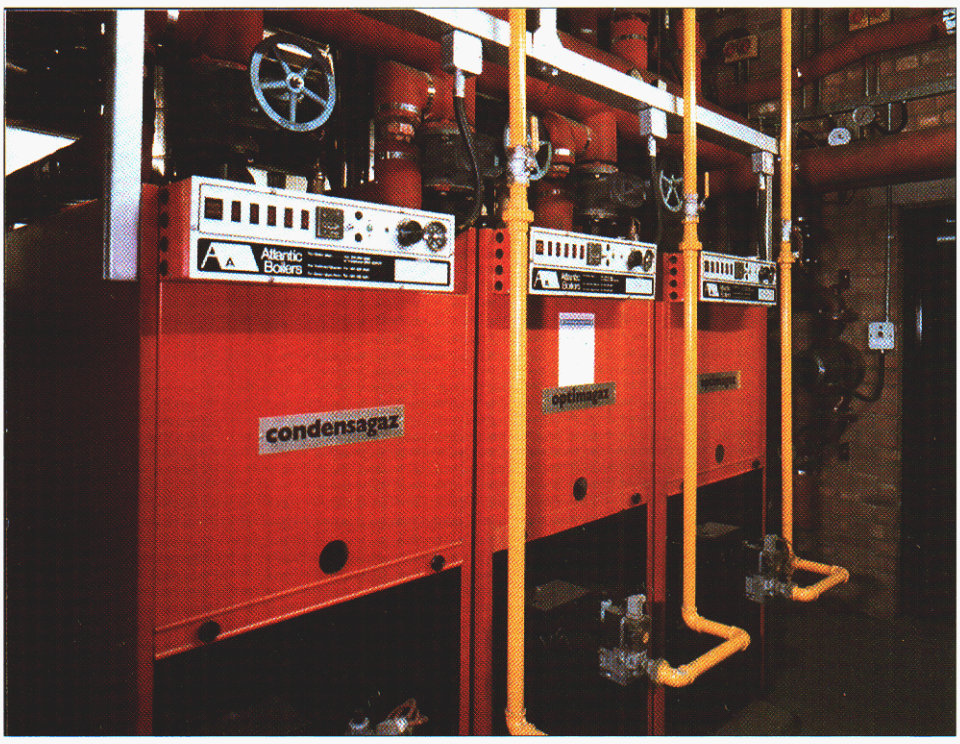
One of the 19 galleries displaying paintings

The supply of steam had already become unreliable, and the survey's main recommendation was to install a separate local boiler plant to supply heat. Three boilers were installed in 1987, one 150 kW Condensagaz condensing boiler and two 150 kW Optimagaz high efficiency boilers. Each unit has a shunt pump and a flue fan operated via a sequence controller. Domestic hot water is provided separately by an electric immersion system, with more remote outlets being supplied by point-of-use water heaters to avoid system losses.

A stainless steel flue rising vertically from each boiler is connected to separate horizontal fan diluted flue headers allowing low level discharge of combustion products. The installation could have benefited from avoiding the use of galvanised mild steel ductwork – which is susceptible to corrosion – for the headers. Each boiler has a condensate drain run in plastic with a trap to avoid combustion products entering the boiler room.

There are three individually pumped heating circuits: one constant temperature heating, one variable temperature radiator/underfloor circuit, and one supplying the six air handling units. The condensing heat exchanger is connected across the air handling circuit supplying heat to preheater and reheater batteries, sized to operate at 60°C flow, 50°C return, to maximise condensing operations of the boiler. Dehumidification in summer requires reheat, giving a year-round load. However, when the preheaters operate, the return temperature drops even further resulting in deeper condensing and thus higher efficiencies.

The air-conditioning plant is closely controlled to provide the correct levels of heating, cooling, dehumidification and humidification. Radiator/underfloor circuits operate only during gallery opening hours and an optimum start controller minimises warm-up times.



One Condensagaz and two Optimagaz boilers

The system operates continuously 7 days per week all year round. To date, the condensing boiler has operated an average of 4000 hours per year, while each of the high efficiency boilers have run for less than 1000 hours/year. This indicates that the condensing boiler has been operated correctly as the lead boiler, thus maximising the potential savings. The sequence controller also allows the high efficiency boilers to be rotated.

Economics

Finding an alternative to the unreliable steam district heating system provided substantial cost savings to the Walker Gallery. Using a condensing boiler has saved a further £1450 per annum over and above these savings, with a payback period of under three years on the additional capital cost. Choosing a mixture of condensing and high efficiency boilers helped to minimise capital cost while still maintaining a high seasonal efficiency.

Reactions

Staff in the Central Services Department at National Museums & Galleries on Merseyside are particularly pleased with the boiler plant, which has proved to be fault-free and reliable during its seven-year life. No additional maintenance costs have been apparent for the condensing boiler. The Energy Manager views the energy savings due to the boiler as an added bonus, and the reduction in CO_2 emissions as a contribution to preventing global warming. These benefits have been achieved without any adverse effect on the conditions required for the preservation of the works of art.

Although they have had problems with heat distribution through some of the old systems in the galleries, the combination of high efficiency and condensing boilers has proved to be very successful and a sound investment. The Energy Manager is so pleased with the condensing boiler that further installations have already been carried out in other museums and galleries.

	Estimated annual running cost (conventional system) £	Estimated annual running cost saving (condensing element) £	Estimated percentage saving %	Overcost (condensing element) £	Approximate payback period (condensing element) years
Walker Art Gallery	13 450	1450	11	3700	2.5
Leighton Buzzard Library	9 300	1550	16	8000	5

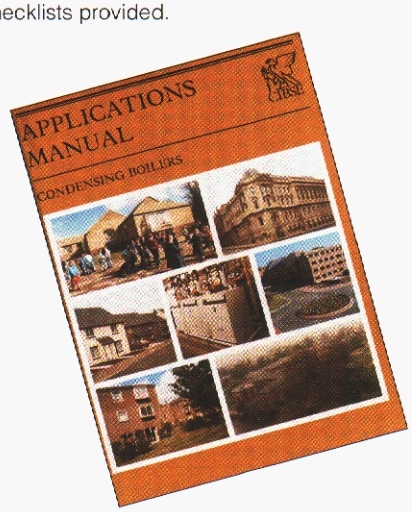
CONCLUSIONS

This Case Study demonstrates that condensing gas boilers are a viable proposition in galleries, museums, libraries and similar buildings. All the engineers concerned are happy with the technology and would install it again. The boilers have proved to be reliable and economic whilst maintaining the internal environment essential for the care of works of art and books, and for attracting people into the buildings that hold them.

FURTHER INFORMATION

This Good Practice Case Study is one of a series on energy efficiency in buildings. These include a number of condensing boiler Case Studies in other types of building. **Good Practice Guide 16** provides practical information on installing condensing boilers in large buildings.

The Chartered Institution of Building Services Engineers (CIBSE) **Applications Manual AM3: Condensing Boilers** gives detailed guidance on all aspects of the subject, including appliance selection, new application yardsticks, system design and economic evaluation. Condensing boilers should be installed and maintained in accordance with the Manual to obtain the maximum benefit. Particular attention should be paid to the installation and commissioning checklists provided.



The information presented in these Case Studies is based on site visits and information provided by the user. Where possible, economic figures have been calculated from the fuel bills. Estimates have been made in cases where these were not available. The co-operation of those responsible for the Case Study buildings in this publication is gratefully acknowledged.

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